REPORT

ON THE

DRAINAGE OF LOUGH NEAGH AND THE LOWER BANN

FURNISHED TO THE

COMMISSIONERS OF PUBLIC WORKS IN IRELAND

BY

FREDERICK J. DICK, M.I.C.E., Engineer to the Commissioners,

31*st May*, 1904.

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LOUGH NEAGH AND LOWER BANN DRAINAGE.

On the 13th October last I received instructions to prepare general plans, estimate, and diagrams (suitable for the purposes of preliminary conferences), of the works which would be feasible, in order to deal with Lough Neagh and the Lower Bann River. After considerable interruption by other pressing matters, this work has now been completed, and I beg to submit the following report, along with relevant maps, sections, and diagrams :—

(1.) *Scheme of* 1889.—It became necessary, in the first instance, to examine the details of the scheme of 1889 proposed by the late Mr. Gamble (not on behalf of the Board of Works). The objects proposed to be attained by that scheme, at an estimated expenditure for works of £63,370, were (*a*) to secure a general winter average flood level for Lough Neagh of 47·50 feet above the "Lough Neagh datum" (which is a certain fixed point at about the level of low water of ordinary spring tides at Coleraine), or, in other words, to secure a general winter average flood level six inches lower than the old summer level of Lough Neagh, which was 48·00 above datum, prior to the year 1859 ; (*b*) to secure a level for Lough Neagh during heavy winter floods not higher than the old summer level ; (*c*) to secure a level for Lough Neagh during extreme maximum floods such as that of February, 1877 (of a class, it may be here observed, not likely to occur more than once in 50 years), not higher than six inches above the old summer level ; and (*d*) to retain the summer or navigation level at two feet below the old summer level (which is its present general height, although it will be seen, on referring to Diagram No. 1, that Lough Neagh has frequently fallen one foot lower (or to 45·00) during the summer of the past 45 years). These objects were intended to be attained by the insertion of 300 feet of sluices in the Weir at Toome, having their sills at 43·00 above datum, by excavating the river channels between Toome and Lough Beg, at Portglenone, above Portna, and between Loughans and the Cutts Weir ; by embanking the river between Carnroe and the Derry Central Railway Bridge on the Bann ; and by lowering the weirs at Portna, Movanagher, Carnroe, and the Cutts, incidentally retaining the adjoining navigation works at a depth of five feet.

(2.) *Analysis of the foregoing.*—A rigorous analysis of the flood of December, 1876, to March, 1877, which reached its highest level in Lough Neagh on February 2nd and 3rd, has shown that some of the assumptions upon which Mr. Gamble's calculations were based are unfortunately not borne out by the facts as revealed by the gauges at Toome and Portna. During part of the time while the flood was rising in January heavy flood water was added to the river between Toome and Portna. This was not sufficiently considered in the calculations of 1889. The channels then designed were intended to carry 600,000 cubic feet per minute below Toome, with Lough Neagh six inches below the old summer level (*i.e.*, at 47·50) and not more than the same quantity at Portna, nearly sixteen miles further down, whereas the discharge at Portna is sometimes 20 per cent. and upwards greater than at Toome. Moreover, the maximum discharge at Toome has to reach 720,000 cubic feet per minute, with correspondingly greater though varying discharges at Portna, in order to deal to the degree indicated hereinafter with such a flood as that of 1876-77. Again the now suggested works, although of considerably greater discharging capacity than in the scheme of 1889, would, with a moderate increase at Portna, discharge only 570,000 cubic feet per minute at Toome, when Lough Neagh is at 47·50; and with heavy flood water added between Toome and Portna only 530,000 at Toome with Lough Neagh at 47·50. In fact, apart from the insufficient provision for added flood water below Toome, the discharging power of the channels proposed in 1889 was somewhat over-estimated.

(3.) *Revision of Scheme.*—For these and other reasons it became necessary to revise considerably the design of the works between Toome and Portna in the first instance, as this portion of the river commencing with the Lough Neagh approach to the Toome Weir constitutes the key to the problem. The discharges, under varying circumstances, of the proposed channels have been carefully calculated in the light of the most recent and reliable experiments with rivers of similar general hydraulic depth and character, and they have also been graded in a more uniform manner, to minimise silting and facilitate maintenance. (See note at end of this report.)

But although it has been found necessary to have sills of the proposed sluices at Toome a foot lower than intended in 1889, and to very considerably increase the quantity of excavation in this reach of the river and above Toome Weir, yet the result of the now suggested works as applied to the exceptional flood of 1876–77 (which is necessarily a severe criterion of any scheme), is still not within the limits contemplated in 1889 as to height; and it will be seen from diagram No. 2 that had the works now proposed been in existence in 1876, the level of Lough Neagh during that flood would have averaged for forty-five days 9½ inches above the old summer level, including February 2nd and 3rd, 1877, upon which two days it would have stood at 15½ inches above the same.

On the other hand, all other floods which have occurred since 1859 would certainly have passed without Lough Neagh rising above the old summer level, had the works now suggested been in existence since that date and efficiently maintained. Ordinary floods would in general have been about 6 inches to 1 foot lower than the old summer level.

It may be said that the foregoing is the utmost that can be achieved within the limits of any reasonable expenditure. To pass such a flood as that of February, 1877, without allowing Lough Neagh to rise above the old summer level, would more than double the cost of the works now suggested.

(4.) *Cost.*—The cost of the proposed works is not only much increased as compared with the proposals of 1889 by the additional cuttings necessary between Toome and Portna and in the Lough Neagh approach to the Toome Weir, but it is further increased by the fact that the maximum discharges in the lower reaches approaching Coleraine will also be greater, and the embankments between Carnroe and the Derry Central Railway Bridge would have to be about two and a half feet higher than had been provided for. In the estimate of 1889 no provision was made for the proper protection of these embankments from the action of burrowing animals, nor for the numerous flap-sluices required to connect with the back drains, nor to any sufficient degree for the land occupied by the embankments and required for the disposal of the spoil from other parts of the river. The embankments, it may be mentioned, are to protect about 1,200 acres of land from the increased flood discharges.

In the following statement the estimate prepared in connection with the Bill of 1889, and that for the scheme now suggested, are placed side by side for purposes of comparison :—

—	Estimate, 1889.	Estimate, 1904.
	£	£
Alterations in Weir at Cutts, ...	80	100
Rock excavation adjoining Cutts Weir, ...	1,500	1,750
Excavation in River, Cutts to Loughans, ...	5,250	5,250
Do. Loughans to Derry Central Railway Bridge,	5,500	5,500
Do. at Agivey River, ...	330	330
Embankments—Derry Central Railway Bridge to Carnroe,	6,000	21,782
Lowering Carnroe, Movanagher, and Portna Weirs, ...	400	900
Carried forward, ...	£19,060	£35,612

TABLE—*continued*.

—	Estimate, 1889.	Estimate, 1904.
Brought forward, ...	£ 19,060	£ 35,612
Excavation below Movanagher Weir, ...	Nil.	600
Do. above do.	Nil.	450
Do. below Portna Weir, ...	Nil.	1,000
Rock excavation—Portna Weir to Portna Quay, ...	6,900	21,700
Excavation—Portna Quay to Claudy River, ...	4,500	5,800
Do. Portglenone, ...	9,750	15,750
Do. Lough Beg to near Toome, ...	9,150	18,000
Do. in Toome Weir Basin, ...	2,450	2,900
Sluices at Toome, sills at 48·00, ...	5,000	—
Do. do. at 42·00, ...	—	7,000
Cleaning above Toome Weir, ...	800	—
Excavation do. to 41·50, ...	—	10,000
Repairs to Toome Weir, ...	—	2,000
	57,610	120,812
Contingencies, 10%	5,760	12,188
Total for works only, ...	63,370	133,000
"Land, etc.,"	1,630	—
Land for spoil and embankments, 200 acres, ...	—	6,000
Promotion, Law, Compensation, etc., ...	—	6,000
Engineering, ...	—	5,000
	£65,000	£150,000

(5.) *Moyola River Outlet.*—In order to lessen the silting caused in the vicinity of the Toome Weir by the flood discharges from the Moyola River, the Engineer of the Lough Neagh Drainage Trustees suggested that the outlet of that river into Lough Neagh should be diverted to the westward, where it would discharge into deep water. This is a question of capital outlay *versus* maintenance, and the diversion would be a costly business. It was not included in the scheme of 1889, nor is it included in the works now suggested, because, so far as I can at present judge, the balance of economy seems in favour of annual maintenance.

(6.) *Flood Levels of Lough Neagh.*—Diagram No. 1 shows that the effect during the past 45 years of the works designed by Mr. M'Mahon, and carried out by the Board of Works, has been

(*a*) The maximum level of Lough Neagh caused by extraordinary winter floods such as that of 1877, has been about four feet lower than that produced by similar floods prior to 1859 (or from 56·00 to 52·00).

(*b*) The level of Lough Neagh caused by ordinary winter floods has been 3 feet 1 inch, on the average, lower than prior to 1859 (or from 51·64 to 48·54.)

(*c*) The summer (or navigation) level has been two feet lower than prior to 1859 (48·00 to 46·00.)

In view of these facts it is hardly possible on general grounds, and apart from the promise of absolute immunity from a higher level than 48·00 for Lough Neagh given by Mr. M'Mahon, to regard such works otherwise than as having been fairly successful.

The effect of the works now suggested, as compared with the conditions prior to 1859, would be :—

(*d*) The maximum height of Lough Neagh produced by extraordinary winter floods such as that of 1877, would be about 6 feet 8½ inches lower than that caused by similar floods prior to 1859 (56·00 to 49·30.)

(*e*) The level of Lough Neagh caused by ordinary winter floods would be about 4 feet 2 inches to 4 feet 8 inches lower than prior to 1859 (51·64 to 47·50 and 47·00.)

(*f*) The summer level of Lough Neagh would remain as at present.

(7.) *Alleged insufficient completion of the works of* 1859.—With regard to the base of some of the dividing dams having been left in (mentioned in the First Report, p. 35, of the Allport Commission of 1887), this, so far as I can find, occurred at a few places down stream from Portna, where their existence, owing to the 14 feet drop at Portna, has never in the smallest degree influenced the flood heights of Lough Neagh.

(8.) *Lands affected.*—As for two days in the winter of 1876–77 Lough Neagh actually reached its level during ordinary winter floods prior to 1859 ; as the proposed works would at all times keep Lough Neagh below or at its old summer level except on the rare occasion of a flood similar to that of 1876–77, during any recurrence of which Lough Neagh would be about 2 feet 8 inches below its actual maximum height in 1877, when the culminating point of the flood was reached ; and as the proposed works would also, to some extent, improve the protection from floods in the lands adjacent to the lower Bann, it is evident that the whole of the injured lands scheduled in the Drainage Award of 4th April, 1859, amounting to 29,597 acres, would be benefited to some extent by the suggested works.

An examination of Diagram No. 1 shows, however, that the benefit would not be very great, seeing that, as a rule, the winter floods during the past 45 years have only averaged 6½ inches above the old summer level (taking the highest in each year) ; that on only eight separate occasions did Lough Neagh reach or exceed 2 feet in height above the same ; that during the seven months from April to October inclusive on only one occasion during 45 years (namely, in 1877, the latter part of the very exceptional flood of February) did Lough Neagh rise 1 foot above the old summer level ; that on only three other separate occasions was it as much as 4 inches above the old summer level ; and that during the latter six of these seven months the level of Lough Neagh was practically steady at 2 feet below the old summer level, or, in other words, at the navigation level originally intended by Mr. M'Mahon.

When Lough Neagh stands at the old summer level, the flood level of the river at Portadown varies generally from about 50·00 to 51·00 or more, according to the flood volume of the River Bann, but the channel requires to be properly maintained, because it is liable to become narrower owing to the sedgy margins, and to silt up, thus forcing up the flood levels at Portadown.

Now, it should be especially noted that Drumnakelly and Ballyworkan bogs above and near to Portadown (see Map No. 10*) have since 1859 been cut away to 2 feet below the old summer level of Lough Neagh, from which these bogs are distant ten miles up-stream. Moreover, on 31st July, 1890, Drumnakelly bog was partly flooded when Lough Neagh was 2 feet 6 inches below the old summer level. And it is obvious that when Lough Neagh is at the old summer level and the upper Bann in flood, the water may stand 5 feet deep on these bog lands above Portadown. · And that even with Lough Neagh at its proposed levels under the suggested scheme during ordinary winter floods, the water would still be 4 feet to 4½ feet deep on these lands, which ought never to have been cut down to their present level. If Mr. M'Mahon intended Lough Neagh to be at the old summer level (48·00) during floods, he certainly never promised that there would be no fall of 2 or 3 feet or more in the upper Bann River between Portadown and Lough Neagh during floods. Nor for the same reason should artisans' dwellings have been built since 1859 upon ground at Portadown at levels but little above the old summer level of Lough Neagh. Nor should land ten miles up the course of the river from Lough Neagh at such levels have been turned to tillage since 1859.

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* Not printed.

No financially feasible scheme for keeping down Lough Neagh could remedy such regrettable mistakes as the foregoing, for which the Government are in no way responsible.

Yet it is the inevitable result of such mistakes, injury to health, crops, &c., that is now apparently sought to be charged against the Government as a "defect" in the 1859 scheme, which the Government should be called upon to remedy.

Had such bog lands been at their present level prior to 1859 the water would sometimes have stood 12 feet deep upon them, or more.

To relieve such lands from the possibility of being covered with water would involve the abandonment of all navigations connected with the Lough, including the Lagan navigation, the upper part of the Newry navigation, the Ulster and Tyrone navigations, the Ballinamore and Ballyconnell navigation, the Blackwater navigation, the upper Bann navigation, the lower Bann navigation, the harbours near Antrim and Lurgan, &c., or in the alternative a long series of very costly works to retain them, in connection with the lowered level of Lough Neagh; and would also involve very heavy works from above Portadown to Lough Neagh; the lowering of the summer level of Lough Neagh about 5 or 6 feet or more; and enormously costly works at the outlet of Lough Neagh and in the lower Bann River. The amount of money required to accomplish all this has not been estimated, but it is hardly necessary to say that it would reach a figure out of all proportion to the very restricted area and extent of special benefit.

The levels of the land in the vicinity of Portadown and at other points are shown on maps Nos. 8, 9, and 10.*

Mr. W. J. O'Neill, the Engineer of the Lough Neagh Drainage Trustees, stated in a report of 1st March last to his Trustees :—

> There are large tracts of bog lands around Lough Neagh which have been cut down to summer level, or 1 to 2 feet above it, or 46·00, 47·00, or 48·00 above datum, *on which, in some cases, dwellings have been erected*, and they are referred to as proofs that the district has not been benefited by the Drainage Works.
>
> The Commissioners of Public Works are correct in assuming that the summer floods have not caused any damage in the district since the completion of the works, with the following exceptions, viz :—
>
> 1. In June and July, 1860, serious damage occurred to the meadows and cropping lands around Portmore Lough in the County of Antrim, owing to the insufficient sectional area of the Tunny Cut, which was 10 feet bottom width and 2 feet under summer level. The trustees, aided by the late landlord, lowered this cut 4 feet under summer level, 10 feet bottom and side slopes of 1 to 1 ; thus Portmore Lough is kept within a few inches of the same level as Lough Neagh in the heaviest rainfall.
>
> 2. At the same time there was also a very high flood on the lands of Tullyroan, in the County of Armagh, and along the valley of the Tall River, owing to the obstructed condition of the new Tall and Callan Cut, which having then been recently made through a considerable length of deep bog—where the excavation was from 9 to 32 feet in depth—the pressure on each side caused the bog bottom to rise and produce the obstruction.
>
> The Trustees, after about two years' work, succeeded in getting it cleared out to the proper depth, since which it has been maintained, and there have not been any summer floods since.

It will be noted from the foregoing that any damage caused by summer floods since 1859 has never been due to the levels of Lough Neagh, but was due solely to local imperfections in arterial drainage, which were subsequently remedied.

(9.) *Maps and Drawings.*—Map No. 11* shows the general extent of the suggested works, and the positions of the cross sections shown on drawings Nos. 18 to 52.*

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* Not printed.

Drawings Nos. 12 to 17* show the longitudinal section of the lower Bann. On these the suggested cuttings are coloured pink and the embankments yellow. Drawing No. 54* shows the type of sluices proposed at Toome, with sills at 42·00. Drawing No. 53* shows the alterations proposed to the weirs at Portna, Movanagher, Carnroe, and Cutts, incidentally retaining a 5 feet navigation. Other maps and diagrams have already been referred to.

(10.) *Retention of Navigation at a reduced depth.*—It should be here observed that any further lowering of the weirs would imply on the one hand the abandonment of the lower Bann navigation and on the other a lowering of the maximum flood level of Lough Neagh of not more than about an inch; so that no useful object would be attained by such further lowering, that is to say, so long as the summer navigation level of Lough Neagh remains as at present.

In order, however, to render the Lower Bann navigation a useful one, an opening span would have to be introduced into the bridge at Coleraine. But as this is a matter outside of the scope of the drainage question, no provision has been made for this in the present estimate.

(11.) *Proposed Minimum Winter Level of Lough Neagh.*—It will be seen from diagram No. 1 that it is proposed, were the present scheme adopted, to keep the level of Lough Neagh in winter, except during floods, as nearly as possible six inches below the present and proposed summer level. This is in order to provide a certain amount of storage for flood water, and it would have an appreciable effect in keeping down the level of ordinary floods. It may be noted, however, that it would have practically no effect in keeping down the highest or culminating level of floods like that of 1876-77 below the figure given in (*d*) of section (6) above, as compared with an initial level of 46·00 when the flood commenced. This is because the initial discharging power of the sluices and lower Bann, after the sluices were opened full, would be less with Lough Neagh at the lower level, and this would tell in a long protracted flood.

(12.) *Summer Level.*—The summer level should, however, be kept up to its present level so long as there is water available to do so. It would unavoidably fall, as it has done in the past, below that level when the evaporation in Lough Neagh exceeds the supply. Provision has been made in the Estimate for securing a practically watertight weir at Toome, and losses due to leakage alone during summer would not occur to any appreciable extent.

(13.) *Summary.*—(*a*) During the six months from May to October, inclusive, the summer level of Lough Neagh would remain as at present. During the past forty-five years it remained practically at that level during these months, except in a few isolated cases, where it rose from 1½ feet to 2 feet above it during short floods. After the suggested works were carried out, such floods would not cause a rise of more than 1 foot, and often less. The difference, having regard to the isolated character of such cases, is not great. It means a slightly improved outfall for about 18,000 acres, but this would only apply in summer floods. Normally there would be no improvement whatever in these months. No damage from summer floods, due to the level of Lough Neagh, has occurred during the past forty-five years. It should be remembered that under the suggested scheme the sluices at Toome would not be much open during those months, their function then being chiefly to maintain the present summer, or navigation, level of Lough Neagh.

(*b*) The effect of the suggested works is therefore practically confined to the lowering of the height of winter floods, or those occurring between November and April. These, instead of rising 2 to 2½ feet above the old summer level in Lough Neagh, would be confined, as regards Lough Neagh, to the old summer level, or below it; and in the surrounding districts, such as at Portsdown, to whatever corresponding height is necessitated by the flood gradients in the rivers and streams. The general lowering of the winter flood heights would be from 2½ to 3 feet. This would directly affect an area of about 17,000 acres of land above Portna, and indirectly about 10,000 acres additional above Portna. About 2,000 acres below Portna would be correspondingly affected as regards winter floods.

* Not printed.

The exception, as regards the limiting, or maximum, height of Lough Neagh in floods, to the foregoing generalisation, is that floods of the 1877 class, which occur about twice in a century, would rise about 15 inches above the old summer level when at their culmination, if the sluices were properly worked. But even in this case the culminating, or maximum, height would be lowered about 2 feet 9 inches as compared with the actual height reached in 1877, so that the generalisation that winter floods would be lowered from 2½ feet to 3 feet applies in this case also.

(c) The value of the benefit to the lands mentioned above which would accrue from the general lowering of all winter floods from 2½ feet to 3 feet is a question which I scarcely feel able to answer. In view of its great importance it is one which might be referred to a land valuer of experience. As to climatic conditions, I hardly think that the lowering of winter flood levels of Lough Neagh 2½ feet to 3 feet would effect any very appreciable improvement.

I have already pointed out that the lowering of winter floods to the extent indicated would by no means free lands at or near the old summer level of Lough Neagh, and miles distant from it, from the effects produced by flood gradients in the rivers and streams when Lough Neagh rises to the old summer level. Still less would it free land like some around Portadown, which has been cut to 2 feet below the old summer level of Lough Neagh.

(d) The areas mentioned do not include the 1,825 acres on the margins of Lough Neagh between the old summer level (48·00) and present summer level (46·00), because this area would, of course, still be flooded every winter under the suggested scheme.

FRED. J. DICK, M.Inst. C.E.

31*st May*, 1904.

NOTE.—In applying the analysis of the 1876–77 flood to the improved channels of the present scheme the well-known formula of Ganguillet and Kutter has been employed, first determining the value of N. proper to be adopted in the case of the Lower Bann River.

This was fixed at N = 0·025, after considering the following experiments made in the cases of rivers of similar character and hydraulic depth :—

Name of River.	Hydraulic Mean Depth, ft.	Surface Inclination.	Actual Mean Velocity, ft. per sec.	Calculated Velocity N= 0·025 ft. per sec.	Percentage Error as compared with Actual Mean Velocity.
De la Fourche, ...	15·7	·000044	2·789	2·78	−0·323°/o
Do., ...	15·7	·000045	3·076	2·82	−8·322
Seine, ...	10·9	·00014	3·741	3·40	−9·115
Do., ...	12·19	·00014	3·816	3·82	+0·105
Do., ...	14·5	·00014	4·232	4·30	+1·607
Do., ...	15·02	·00014	4·511	4·40	−2·461
Do., ...	11·24	·000057	2·362	2·46	+4·149
Elbe, ...	5·18	·00037	3·74	3·40	−9·091
Missouri ...	8·05	·000117	3·10	2·70	−12·903
Solani, ...	8·64	·000231	3·98	3·85	−3·266
Wesser, ...	9·44	·0002	4·064	3·83	−5·758
Tiber, ...	9·46	·0001306	3·413	3·12	−8·585
Danube, ...	11·88	·00004	2·25	2·23	−0·889
Rhine, ...	12·11	·000307	5·215	5·46	+4·686
Saone, ...	14·64	·00004	2·369	2·55	+7·640

Average percentage error, ... −2·835°/o

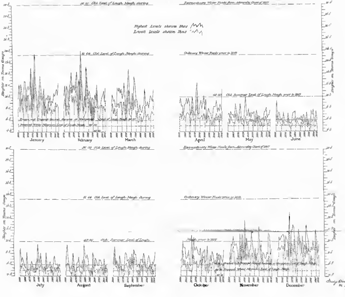
F. J. D.,
31 5/04.

LOWER BANN IMPROVEMENT
DIAGRAM

DIAGRAM Nº1

Showing Highest and Lowest Levels of Lough Neagh in each Month during the past 45 Years

1904



Fredk Dick
M. Inst. C.E.
21 May 1904

LOWER BANN IMPROVEMENT

Diagrams of Flood of 1876-77 showing effect of Proposed Works

DIAGRAM Nº 2

1904

DIAGRAM OF SUPPLY AND DISCHARGE

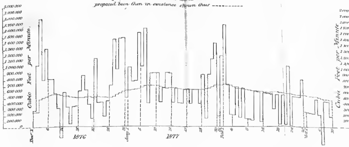
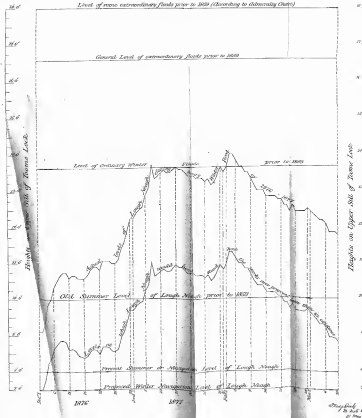


DIAGRAM OF HEIGHTS OF LOUGH NEAGH



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31 May 1904